Morphometric Variation as an element of Phenotypic Diversity in Interior Salmonids

MORPHOMETRIC VARIATION AS AN ELEMENT OF PHENOTYPIC DIVERSITY IN INTERIOR SALMONIDS

FINAL REPORT

TO

BRUCE RIEMAN

ROCKY MOUNTAIN RESEARCH STATION

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Introduction and Background

This collaborative research was set up to do a preliminary examination of the utility of morphometric characters for describing patterns of intraspecific diversity in salmonids. Specifically, the study looked at bull trout (*Salvelinus confluentus*) populations within tributaries to the Lower Clark Fork River drainage flowing into Lake Pend Oreille, Idaho, USA.

The objectives as stated in the contract agreement were three fold:

(i) Determine whether morphometric characteristics of bull trout (and / or cutthroat trout) can be accurately measured from digital photographs of individuals;

(ii) Determine whether morphometric characteristics can be used to discriminate individuals or populations from distinct environments or life history types occurring within the same subbasins, and;

(iii) Collaborate on an interpretation of similarities or differences among morphometric and other phenotypic and genetic characteristics.

The rationale was to investigate further opportunities to describe and understand aquatic biological diversity and integrity. This is one of the most fundamental goals of conservation land management. Such native biological diversity represents evolutionary adaptation to a broad, diverse, physical template, and is characterized by a corresponding suite of ecological forms, strategies, and temporal spatial occurrences that serve to stabilize systems and maximize productivity.

Other previous assessments on this and other salmonid species tended to be at a larger scale. This is true biologically with species being examined and also geographically with most work being done on a broader regional or watershed scale. There is a much more limited understanding of diversity at the smaller scale of individual subbasins (eg. Barbosa and Galdean 1997).

A key step necessary for the guidance of conservation priorities will be the characterization of these smaller scale patterns in diversity. Conservation and restoration of the diversity of life histories, genotypes, and phenotypes both within and among populations represents an important goal for local land management.

The deliverables as stated in the contract agreement were as detailed below. The remainder of this report will be structured about these three italicized topic headings

(1) *Morphometric Measurements* - Describe and demonstrate morphometric measurement, and analytical techniques that have proven useful for discrimination in other species. Provide a protocol of field and photographic measurements useful for the validation of digital photographic based methods, and a template for data sets suitable for analysis.

(2) *Measurement Error and Repeatability* - Describe the variation or error in morphometric measurements made by different personnel, and using different methods (e.g. photo, field, preserved specimen) and make recommendations for mitigating measurement error and variation.

(3) *Analyses* - Conduct a morphometric analysis of at least two data sets each representing at least two distinct populations. Sample sizes included in the analysis will be appropriate to characterize within population variation and characterize the discriminatory power of analyses with varied samples sizes.

Materials and Methods

(1) Morphometric Measurements

All data were taken and provided by the US Forest Service (USFS), with some prior consultation. The morphometric data consisted of two sets. The first and larger data set consisted of up to six morphometric measurements collected from 450 bull trout from five tributaries to Lake Pend Oreille, Idaho, USA. The legitimate and understandable necessity to minimize fish handling and to undertake non-lethal measurements on an US Endangered Species Act listed species limited this approach to up to six measurements. The six potential morphometric measurements consisted anal fin length, caudal fin length, head length, pelvic fin length, upper jaw length, and a body size measure of fork length. The five tributary streams were East Fork Creek, Grouse Creek, Pack Creek, South Gold Creek, and Trestle Creek.

The second and much smaller data set consisted of these same five morphometric measurements and one body length measure obtained from digital photographs taken in the field of a subset of the same 450 bull trout from the first data set. Approximately 80 photographs were taken, and morphometric data measured by the USFS from 39 of these digital photographs was provided by the USFS.

The data from the digital photographs was very limited so was not used at this point for discriminatory analyses. This data should and will ultimately be used, but further discussion is first required with the USFS to clarify some of its data features and collection, and to ensure USFS objectives are met. As well, the full data for all 80 fish should be collected and analyzed. A recurring "rule-of-thumb" sample size for groups in discriminatory analyses is 25 individuals, and this sample size can also be verified as accurate (eg. Haas and McPhail 1991). Recommendations and suggestions are nonetheless made here on how to best collect and use this information. An assessment of its measurement error and repeatability is provided in the subsequent section.

The five morphometric field measurements and fork length field measure were not collected on all 450 bull trout so the data set was analyzed here only for those 338 fish that had complete data available

(appendix A). There actually were 339 bull trout that had complete data available, but Pack Creek was only represented by a single fish. This single Pack Creek fish was left out of the analyses at this stage.

(2) Measurement Error and Repeatability

Measurement error was preliminarily assessed by the USFS on both the field and photographic data sets. Two types of error were examined. In the second case, the field data was directly compared to the photographic data. In the second case, the USFS redid the photographic data collection with another person doing the digitized measurements. These two sets of photographic data were then compared. This provided a preliminary assessment of the repeatability of the field measurements compared to the digital photographs was undertaken by the USFS for those limited number of fish that had both these sets of data. There was no replicate field measurement data for any error assessment. Measurement error in all cases was assessed by linear regression analyses.

(3) Morphometric Analyses

Two overall types of morphometric analyses were undertaken to try to discriminate the bull trout stocks in each tributary stream. The two overall types differ in their procedural approach to adjusting the morphometric measurements for body size. The first overall type were bivariate analyses, where each of the five morphometric measurements was simply divided by fork length for each bull trout. Fork length was used as a single measurement surrogate for body size. This data was then analyzed individually for each of the five morphometric measurements.

The second overall type of analyses were multivariate, where all the morphometric measurements are simultaneously analyzed without reference to any one size measure. Rather, such multivariate analyses are known to produce new independent size and shape variables for each character and fish. The overall shapes of each fish and of their respective groupings into tributary stocks can then be compared against another overall and orthogonal (uncorrelated) measure of size.

Two multivariate analyses were undertaken. The first is principal components analysis (PCA). PCA requires no *a priori* designation of groups. The data here was analyzed for the five morphometric characters excluding the body size measure of fork length. In each case and as is the classic multivariate morphometric interpretation, the first PCA eigenvector was a size vector and the second vector was a shape vector (eg. Haas and McPhail 1991, 2001). The second multivariate analysis is discriminant function analysis (DFA). DFA requires *a priori* group designation and uses this information to maximize between-group variation in relation to within-group variation. DFA does not adjust for allometric size and was thus undertaken on the five morphometric characters after they had each been individually divided by fork length.

Results and Discussion

(1) Morphometric Measurements

The morphometric measurements taken were understandably and legitimately constrained by the circumstances of their field and necessary non-lethal collection. However, these particular

measurements are not those that have been successfully best used elsewhere to distinguish char (*Salvelinus* spp.) at the inter- or intra-specific level. The exception to this is upper jaw length which has been successfully used to discriminate bull trout from other char species (Cavender 1978, Haas and McPhail 1991) and to differentiate bull trout biogeographic groups (Haas and McPhail 2001).

The type of measurements taken should be re-assessed. This should be further based on discussions of variability as seen by people taking measurements or having worked on these fish, as well as on a very complete analysis of the photographic data. The photographs should be fully utilized to provide as much morphometric data as possible so that a full suite of characters can be assessed to determine what might be used to even better distinguish intraspecific variability. This could, and likely should, be further enhanced by a thorough examination and discussion of what characteristics have been successfully used in similar discriminations of bull trout and other salmonid species, particularly char. This did not happen for the present field data collection due to time constraints in carrying out the work.

As well, certain meristic variables have been very successfully used in discriminating char species and groups (Cavender 1978, Haas and McPhail 1991, 2001). The advantage to meristic variables is that they provide more discrete delineations than morphometric characters sometimes do. However, disadvantages to their use have been noted as resulting from measurement error and lack of training in people trying to accurately undertake them (eg. Lee 1990, Haas and McPhail 2001(b), Haas et al. submitted). These disadvantages can be ameliorated to some degree through proper teaching and training (eg. Farmanian et al. 1989).

Another source of discrimination that might be employed from the photographic data is the use of non-traditional variability such as spotting patterns, etc.. I have been able to distinguish char species and 'stocks' based on spotting pattern and type on a small geographic scale, but have not been successful at employing such measures on a larger scale (Haas and McPhail 1991). Such patterns are also often observed and noted by individuals who have worked or fished in a certain drainage basin for lengthy periods of time. The potential for using such non-traditional patterns is also improved if features such as spotting pattern are collected in a rigorous manner that permits their analysis in conjunction with other morphometric variables. By this I mean that spots could be categorized as on the operculum or above and below the lateral line, etc.. Again, a careful examination and use of the photographs would help determine these possibilities and how to best collect the information.

If possible, future assessments should also try to verify that possible confounding factors such as sexual dimorphism and spawning state are not impacting the variables being collected or the analyses being undertaken. As well, the data could be similarly partitioned into suspected life-history types (or perhaps by stream locations) or through the use of already established genetic relationships or parameters.

(2) Measurement Error and Repeatability

Preliminary accuracy assessments by the USFS are presented in Figures 1 and 2 for the morphometric measurement of upper jaw length. Figures 1 and 2 are representative of the error and

repeatability assessments for the other morphometric data, and since the USFS did these analyses they already have the other regression plots.

The assessment of measurement error is preliminary, but errors between the field and photographic data, and within photographic data, do exist. However, such levels of error are easily within that found in the limited number of other studies that have examined such situations (Douglas et al. 1989, 1998, Haas and McPhail 2001(b), Haas et al. submitted). In particular, the error between the field and photographic data sets is higher, but again not unreasonable or outside of expectations and other research experience (Edwards and Morse 1995).

Analyses of measurement errors were not taken further at this stage, but can easily be undertaken (eg. Haas and McPhail 1991). The more general ability of the data set to discriminate between the tributary stocks first requires clarification and discussion with the USFS. It is also not clear how and by what methods the morphometric measurements were collected from the field and photographs. Measurement accuracy may also be easily improved through methodology and through compensation for such photographic factors as parallax.

I am able to discriminate adult steelhead stocks from distinct tributaries in the Skeena River system using the same direct measurements on the fish and from photographs of the fish. As well, I now have specimens and related photographs of juvenile steelhead from the same systems and plan to examine if I can also distinguish the stocks at that life-history stage and in the same manner as for the adults. These analyses and results will be made available to the USFS for consideration with respect to these data here.

I detect an underlying strong concern from the USFS as to whether the photographs can be accurately used to determine morphometric measurements. My suggestion would be that the error which is presently observed can be greatly reduced through careful training and discussion, or by having one person do the measurement work. This all requires further discussion with the USFS prior to further analyses. It also warrants the note that even reasonably high error rates would still remain inconsequential if the data could be used to discriminate intraspecific groupings. Measurement error can certainly be a problem, but it likely is not the major factor to be over-concerned about at this preliminary stage. What should be kept in mind during discussions about where to take these analyses is what characters are likely to work best in discriminations and that those characters be minimally prone to untrained measurement error and be capable of measurement from photographs or on live bull trout (eg. Haas and McPhail 1991, 2001(b), submitted).

Another item to note with respect to measurement error is that there clearly are some strong outlying values in the analyses shown in the upcoming section 3 below. This suggests that particular measurements on particular fish were not done correctly. These should be removed for future analyses and be examined to determine what they might teach about measurement error. As well, measurement error should be examined with respect to body size (eg. Haas and McPhail 2001(b), Haas et al. submitted).

(3) *Morphometric Analyses*

The five morphometric measurements or their multivariate combinations as assessed here are capable of distinguishing the bull trout from the four tributaries at levels of statistical significance. This is the encouraging case even in spite of the preliminary nature of these analyses and assessments. However, the functional value of these distinctions for complete field identification of all five tributaries is presently still somewhat limited. There remains some working overlap in fully discriminating the bull trout stocks in this complete assessment of all these tributaries.

Nonetheless, these analyses are still very preliminary and there are several avenues readily available to potentially increase these discriminations. However, good discussions with the USFS about what their main objectives in this regard are first needed. For instance, which groups is it most desirable to discriminate, or would discrimination within certain size categories or within size categories suffice? As well, the data used here are only very preliminary and other specific morphometric characters or a more full characterization of the shape may greatly enhance the discriminatory power.

The tributary of East Fork Creek was more strongly distinguishable. South Gold Creek was also sometimes more distinct. Of the remaining two tributaries, both were generally more consistently clustered with either East Fork or South Gold creeks. Trestle Creek was generally more similar to East Fork Creek and Grouse Creek was generally more similar to South Gold Creek. In all these cases, it would likely be very interesting to also examine those specific bull trout that are or are not discriminated to see if there are any consistent patterns. These results should all be considered with the preliminary nature of the data and analyses kept in mind.

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FIGURE 1

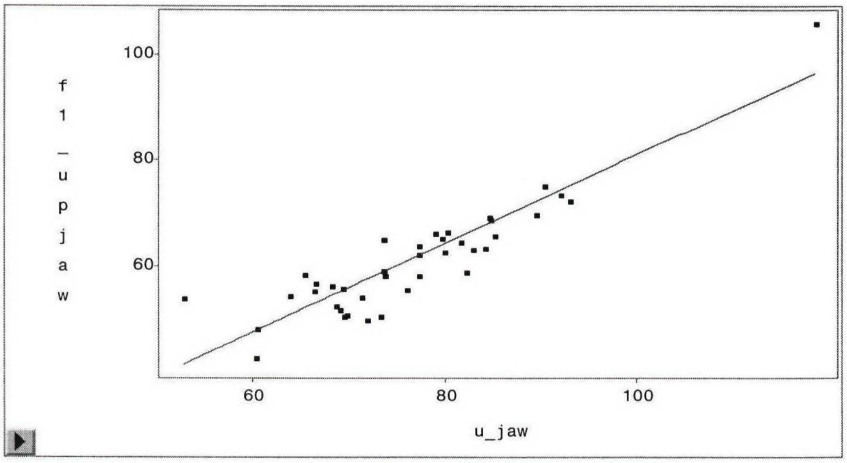
Linear Regression Analysis of Measurement Error

Repeatability of Photographic versus Field Measurements of Upper Jaw Length

f1_upjaw =	u_jaw
Response Distribution:	Normal
Link Function:	Identity

Model Equation

f1_upjaw = - 2.3247 + 0.8335 u_jaw



Parametric Regression Fit

Curve	Degree(Polynomial)	Model DF	Model Mean Square	Error DF	Error Mean Square	R-Square	F Stat	Pr > F
	1	1	3511.6476	37	20.4544	0.8227	171.68	<.0001

Summary of Fit

Mean of Response	61.5018	R-Square	0.8227
Root MSE	4.5227	Adj R-Sq	0.8179

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Stat	Pr > F
Model	1	3511.6476	3511.6476	171.68	<.0001
Error	37	756.8144	20.4544		
C Total	38	4268.4620			

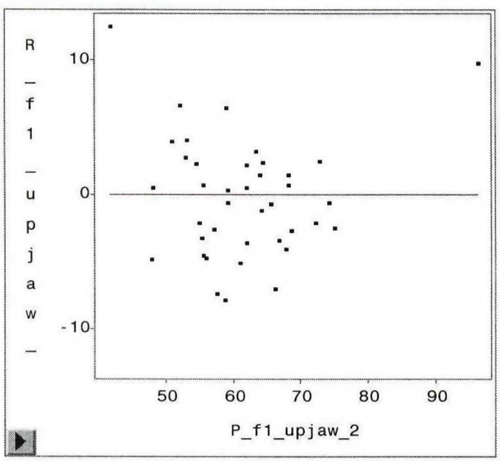


FIGURE 2

Linear Regression Analysis of Measurement Error

Inter-observer Repeatability of Photographic Measurement of Upper Jaw Length

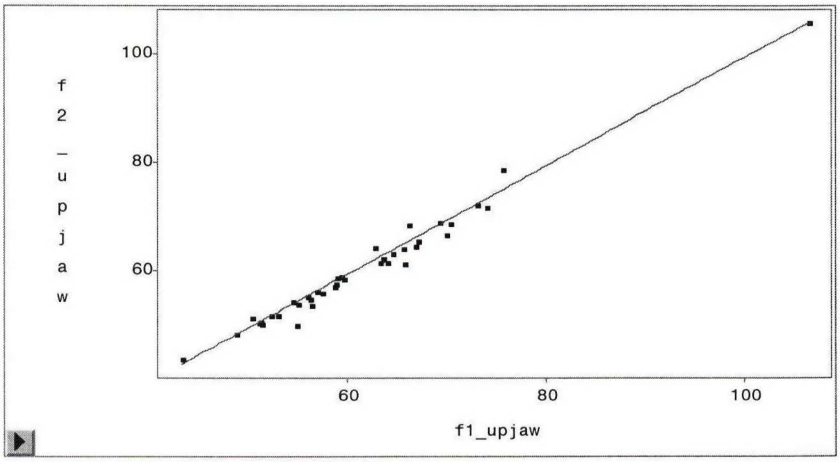
f2_upjaw = f1_upjaw

Response Distribution: Normal

Link Function: Identity

Model Equation

f2_upjaw = - 0.5859 + 0.9997 f1_upjaw



Parametric Regression Fit

Curve	Degree(Polynomial)	Model DF	Model Mean Square	Error DF	Error Mean Square	R-Square	F Stat	Pr > F
	1	1	4252.0531	36	2.3812	0.9802	1785.70	<.0001

Summary of Fit

Mean of Response	60.8000	R-Square	0.9802
Root MSE	1.5431	Adj R-Sq	0.9797

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Stat	Pr > F
Model	1	4252.0531	4252.0531	1785.70	<.0001
Error	36	85.7219	2.3812		
C Total	37	4337.7750			

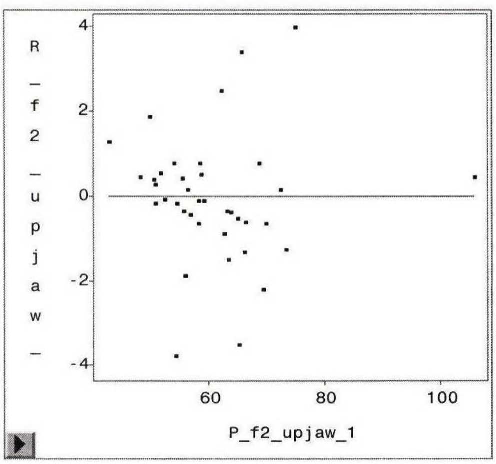


FIGURE 3 (A)

Bivariate Discrimination – ANAL FIN LENGTH

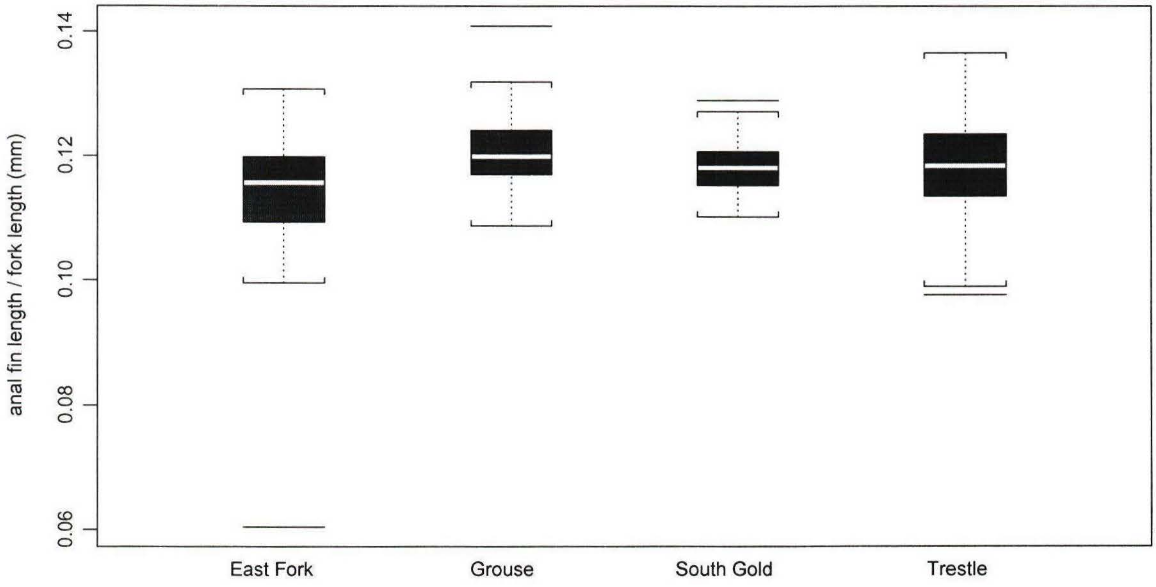


FIGURE 3 (B)

PC2 (Shape) Character Loadings – ANAL FIN LENGTH

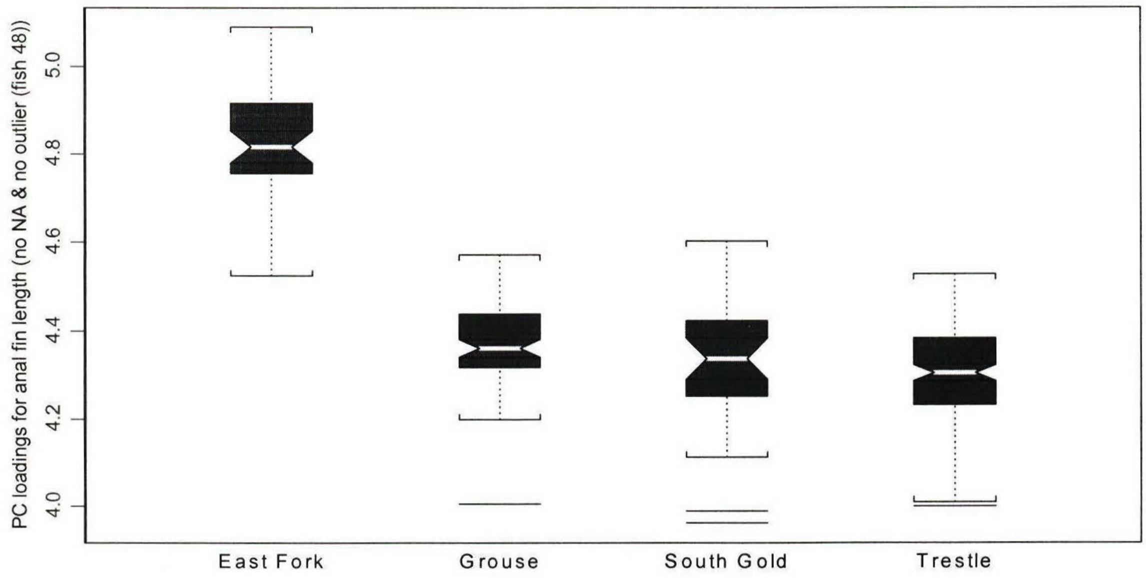


FIGURE 4 (A)

Bivariate Discrimination – CAUDAL

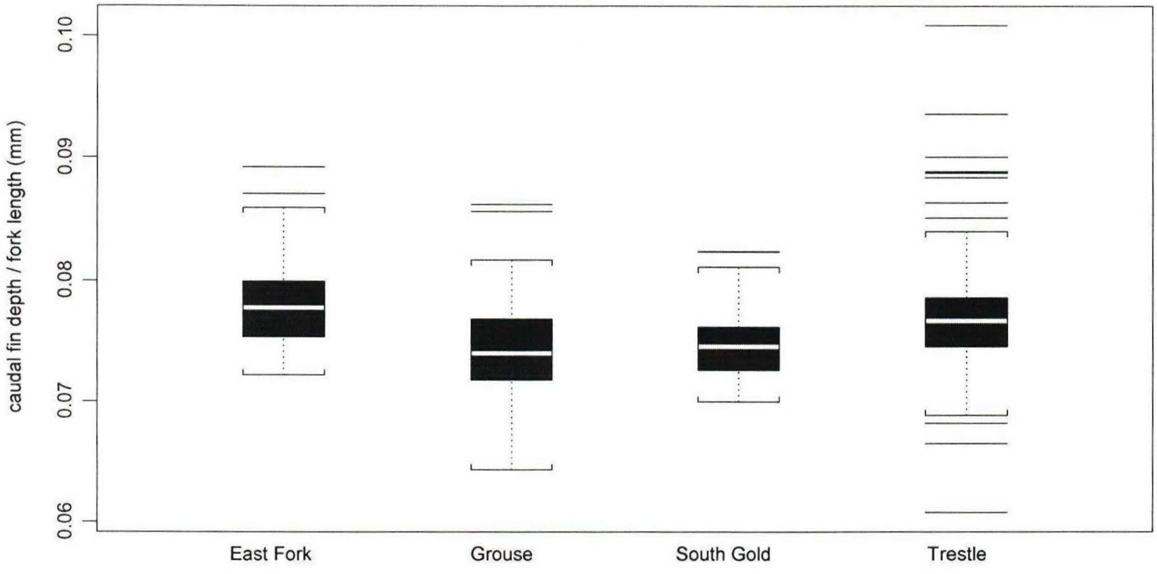


FIGURE 4 (B)

PC2 (Shape) Character Loadings – CAUDAL

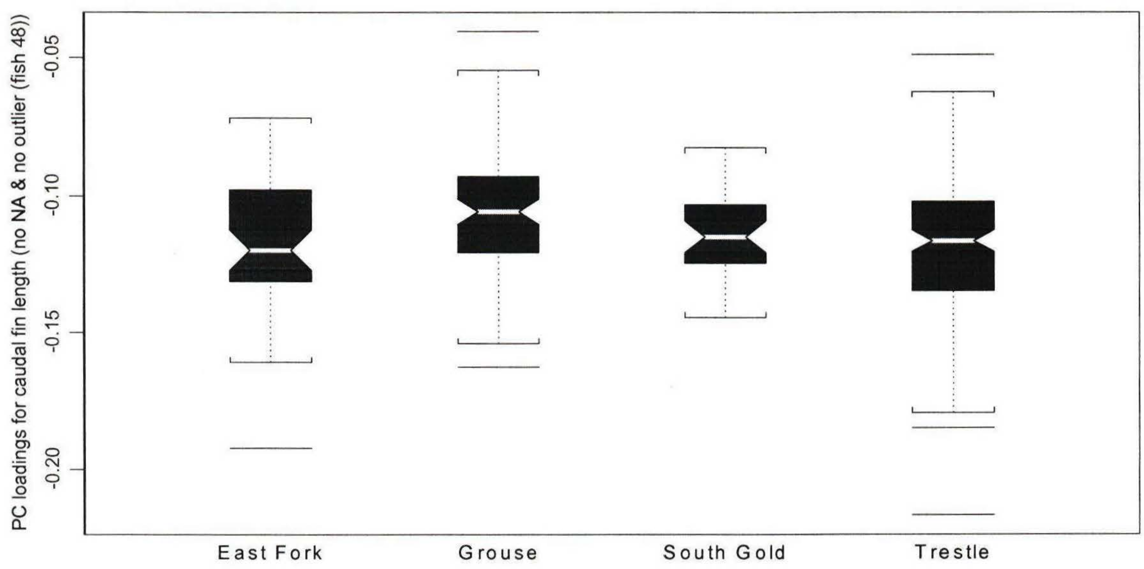


FIGURE 5 (A)

Bivariate Discrimination – HEAD

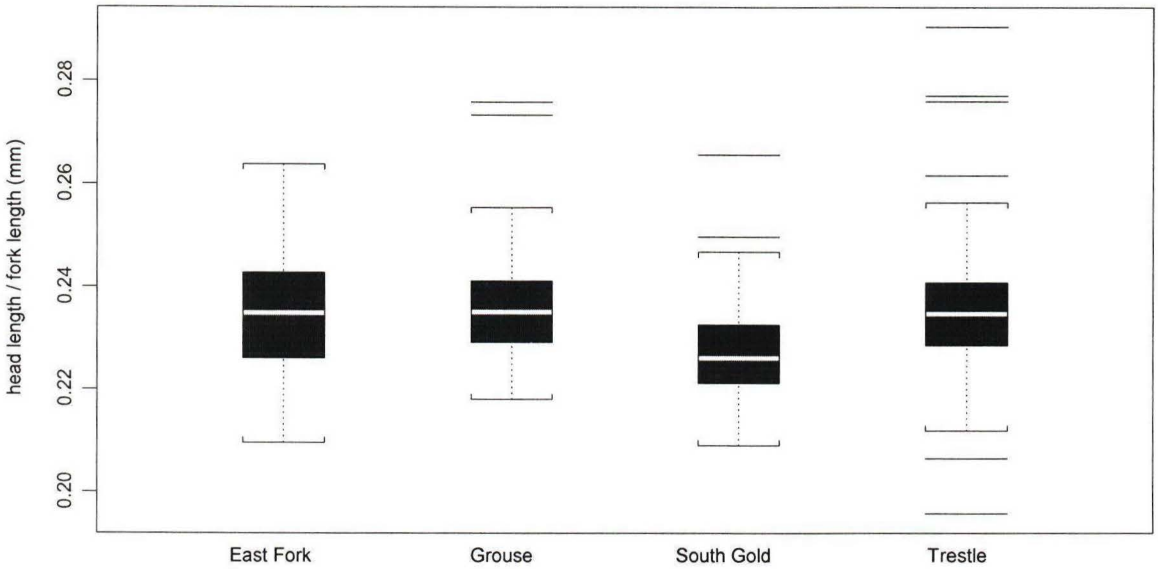


FIGURE 5 (B)

PC2 (Shape) Character Loadings - HEAD

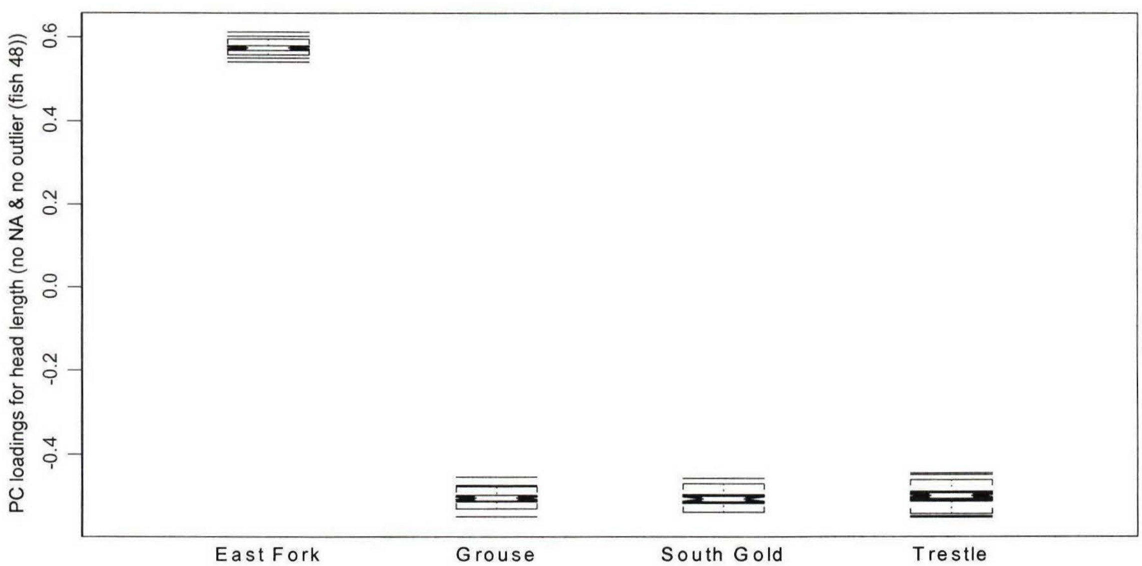


FIGURE 6 (A)

Bivariate Discrimination – PELVIC

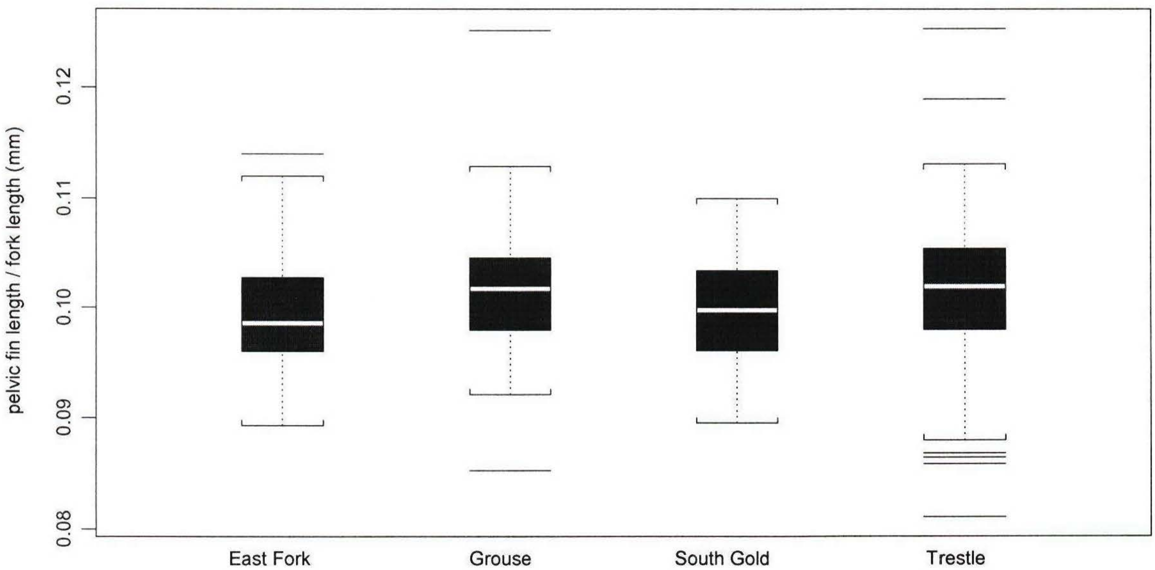


FIGURE 6 (B)

PC 2 (Shape) Character Loadings - PELVIC

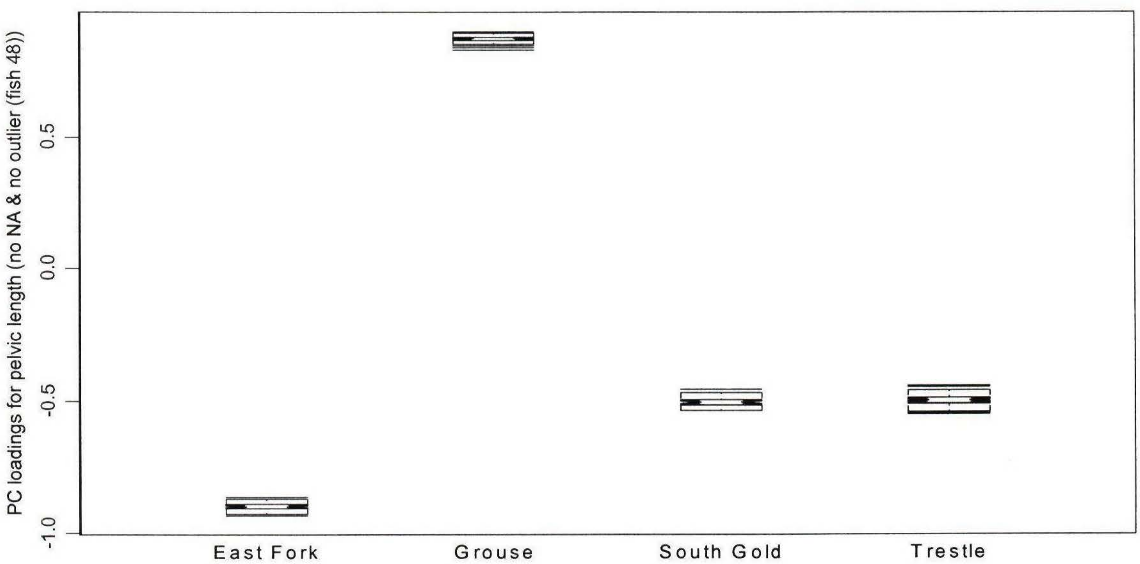


FIGURE 7(A)

Bivariate Discrimination – UPPER JAW

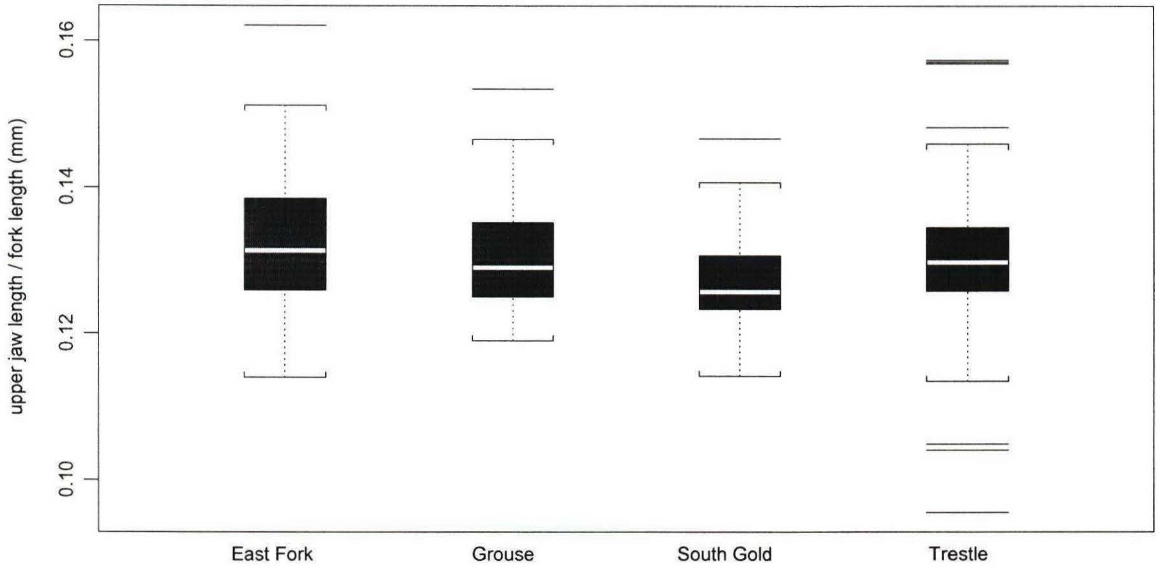


FIGURE 7 (B)

PC2 (Shape) Character Loadings – UPPER JAW

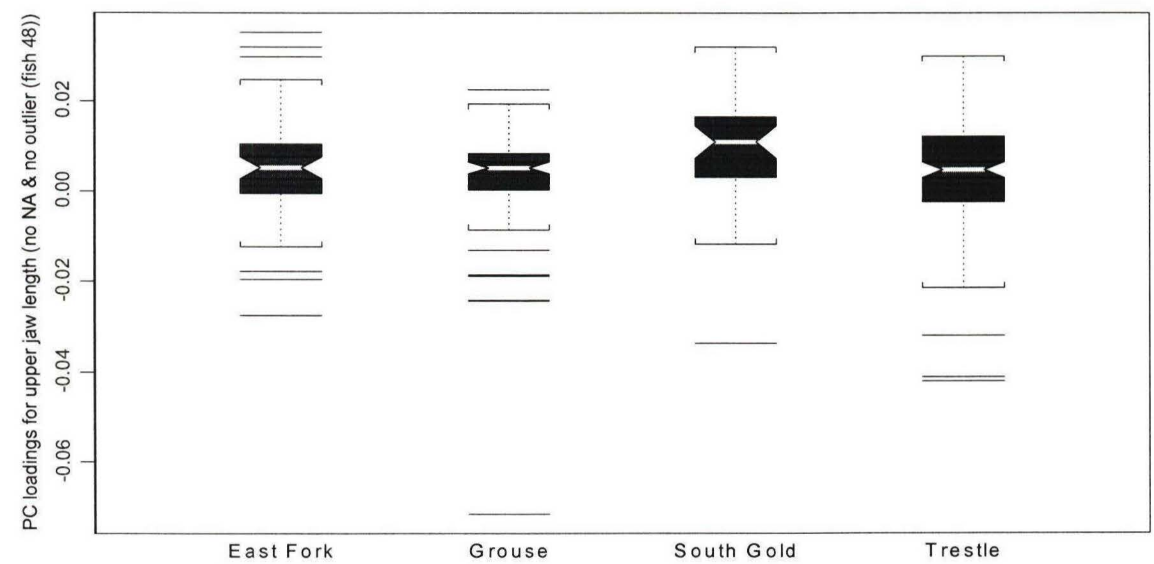


FIGURE 8 (A)

PC2 scores – individual fish (all six morphometric variables)

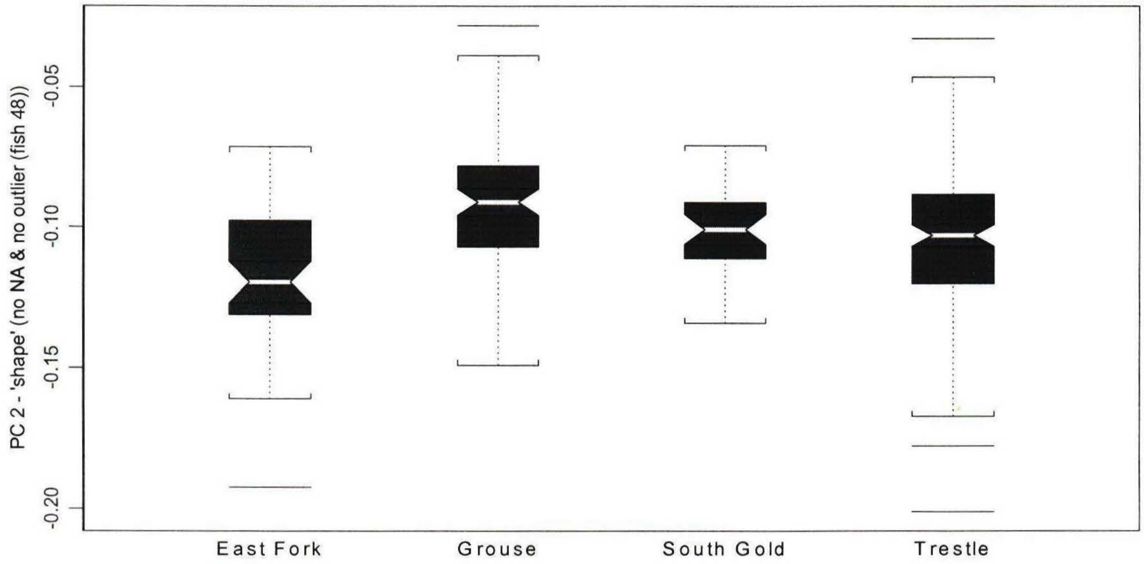


FIGURE 8 (B)

Scatterplot of PC1 (size) versus PC2 (shape) – individual fish

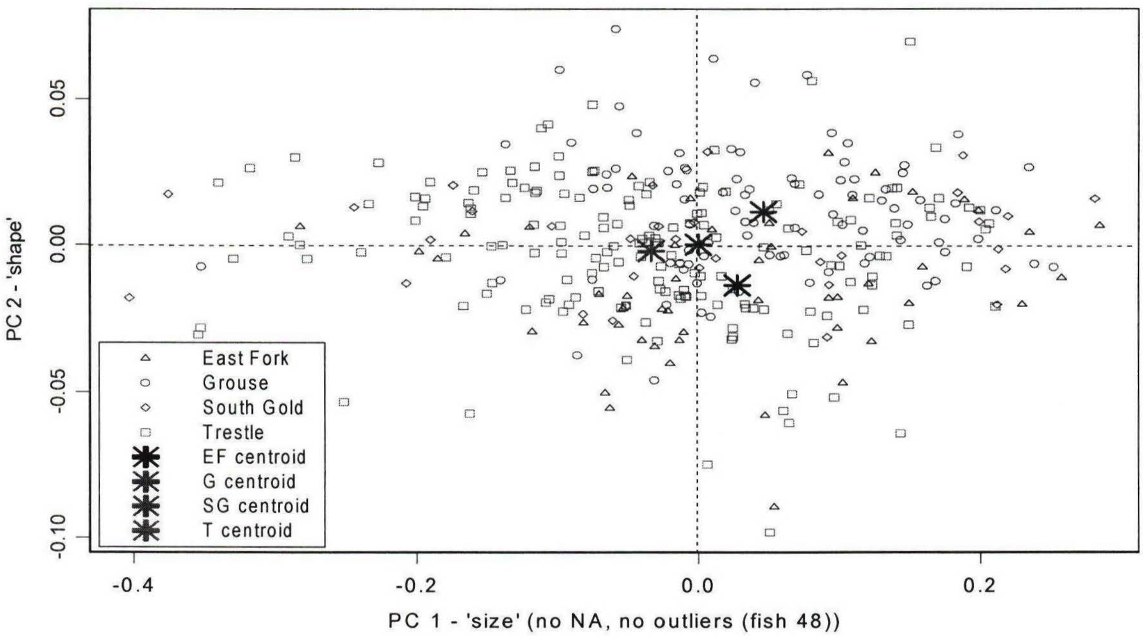
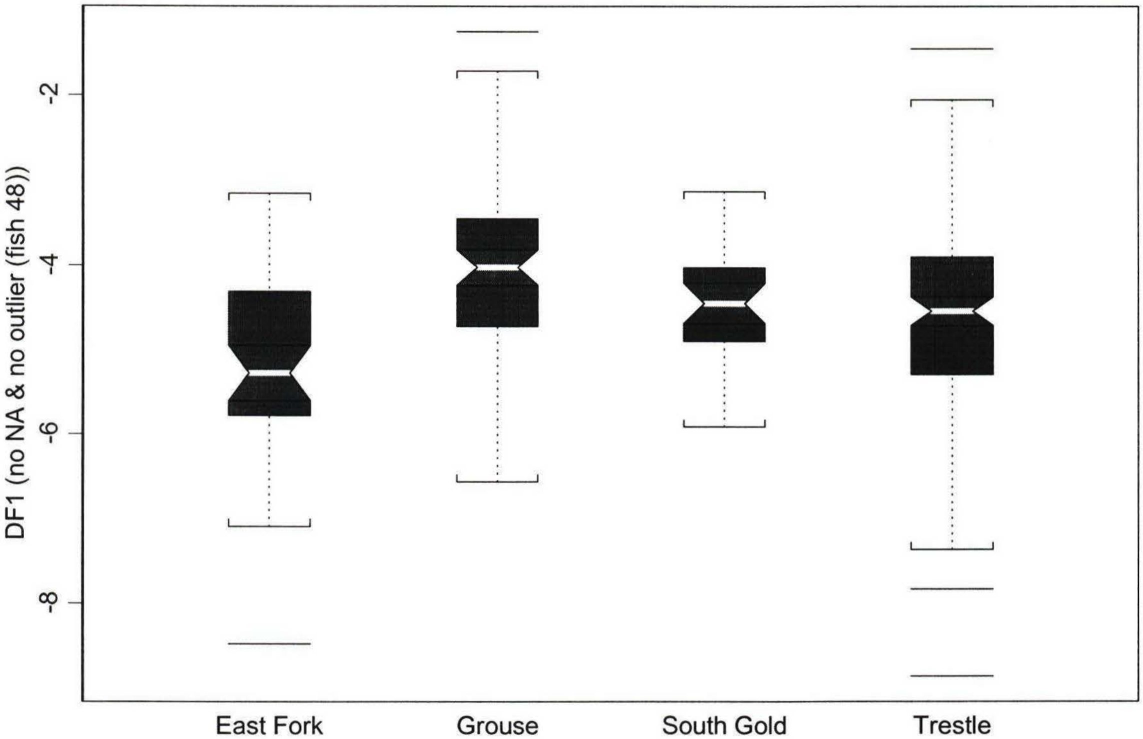


FIGURE 9

Discriminant Function Analysis – individual fish

(all five morphometric characters – not fork length)



APPENDIX A

Morphometric Field Data Set Used for Discriminatory Analyses

STREAM	FISH #	ANAL	CAUDAL	FORK	HEAD	PELVIC	UP JAW
East	1	55.9	39.5	521.0	126.8	49.5	63.6
E	2	71.8	48.2	604.0	134.6	58.4	76.1
E	3	59.2	46.9	595.0	137.6	56.7	73.8
E	4	67.7	49.5	625.0	137.5	60.8	73.7
E	5	58.4	41.9	537.0	120.5	51.2	70.8
E	8	57.5	39.0	509.0	115.2	46.1	61.0
E	9	67.1	47.7	619.0	152.1	56.7	84.9
E	11	59.9	43.8	548.0	119.8	53.6	69.5
E	12	71.1	44.0	574.0	129.6	57.4	71.5
E	14	57.8	40.9	511.0	122.2	48.5	72.9
E	15	66.0	52.2	585.0	131.5	52.4	70.5
E	16	65.0	39.5	543.0	131.2	53.6	70.9
E	18	45.3	30.9	418.0	102.1	42.3	57.9
E	19	67.0	44.5	579.0	131.4	56.0	71.9
E	20	58.8	42.7	555.0	121.9	53.3	73.6
E	21	74.3	45.5	620.0	148.1	64.2	84.6
E	22	76.6	48.7	646.0	147.2	57.7	81.5
E	23	70.2	43.9	580.0	153.0	60.7	80.5
E	24	75.5	48.5	605.0	153.2	65.4	98.1
E	25	59.7	44.0	512.0	117.6	47.9	66.5
E	26	63.2	43.6	540.0	125.1	52.4	69.5
E	27	77.5	48.9	621.0	148.7	61.7	81.3
E	28	65.5	43.6	553.0	132.1	57.8	75.7
E	29	60.0	41.0	528.0	114.9	50.8	69.9
E	30	60.2	40.5	540.0	127.3	52.8	61.6
E	32	82.8	51.9	633.0	153.0	68.3	93.6
E	33	76.9	47.7	619.0	153.0	65.7	90.5
E	34	54.1	37.1	450.0	116.5	51.3	67.4
E	35	59.2	42.6	535.0	124.3	51.5	70.1
E	36	61.5	42.5	526.0	126.3	52.7	69.5
E	37	65.1	42.2	549.0	140.0	56.4	80.0
E	38	51.7	34.6	444.0	108.1	44.8	60.8
E	40	59.6	40.9	502.0	131.1	55.5	73.4
E	41	55.2	34.8	482.0	111.8	45.4	59.9
E	42	69.0	47.1	597.0	141.5	61.0	84.7
E	43	56.4	42.9	516.0	120.7	50.8	65.0
E	44	56.5	39.1	532.0	121.4	51.1	66.7
E	45	61.0	42.0	542.0	121.2	53.2	69.3
E	46	82.9	55.2	634.0	153.0	71.0	95.9
E	47	51.4	34.6	476.0	109.5	46.6	58.7
E	48	62.4	38.4	500.0	122.2	54.1	69.2
E	49	73.5	44.1	591.0	143.5	61.4	85.7
E	50	77.4	52.8	677.0	153.0	69.0	89.5
E	51	68.0	42.1	566.0	140.1	62.8	84.3
E	52	87.8	52.9	730.0	153.0	72.9	93.3
E	53	60.2	40.9	556.0	125.6	54.6	70.1
E	55	68.0	46.4	590.0	142.4	58.3	81.3
E	56	33.6	45.4	556.0	125.7	52.2	70.3
E	57	63.5	40.9	550.0	131.1	55.9	72.4

E	58	71.0	46.8	599.0	138.7	59.2	74.1
Grouse	1	79.5	51.5	695.0	153.0	69.6	90.4
G	2	79.1	45.4	620.0	153.0	65.8	89.6
G	3	66.6	38.2	549.0	127.2	54.7	68.3
G	4	72.6	45.2	595.0	138.1	62.2	76.0
G	5	76.6	44.7	618.0	147.4	63.6	82.3
G	6	59.2	32.8	510.0	120.3	52.3	65.9
G	7	75.2	47.0	653.0	149.8	66.0	84.3
G	8	68.5	39.3	563.0	130.9	56.1	73.2
G	9	65.3	36.7	532.0	125.5	53.3	65.6
G	10	66.1	41.3	573.0	124.9	52.8	71.0
G	11	61.2	36.9	535.0	121.7	51.9	65.4
G	12	63.4	35.1	540.0	122.3	53.1	66.8
G	13	70.0	43.4	590.0	135.8	58.9	73.6
G	14	68.8	40.2	574.0	128.4	54.5	71.0
G	15	75.8	43.7	612.0	136.4	61.8	73.9
G	16	75.8	47.1	625.0	150.5	66.6	74.4
G	17	67.9	41.8	579.0	134.4	54.3	73.0
G	18	76.2	49.6	609.0	153.0	60.6	86.8
G	19	65.1	41.5	575.0	131.5	58.7	72.3
G	20	70.4	46.4	600.0	143.3	61.0	81.6
G	21	62.4	40.6	560.0	132.1	54.3	73.7
G	22	62.2	41.6	560.0	128.7	53.3	72.1
G	23	63.6	39.2	555.0	128.0	55.3	69.4
G	24	72.6	42.7	585.0	142.1	63.8	79.0
G	25	72.2	41.8	590.0	136.8	57.8	73.8
G	26	73.9	45.6	591.0	142.8	63.0	83.0
G	27	63.3	40.4	554.0	135.0	57.2	79.2
G	28	73.8	46.6	579.0	146.3	64.5	83.3
G	29	74.6	43.8	600.0	140.7	60.6	79.8
G	30	75.9	47.0	634.0	153.0	65.0	88.9
G	31	75.5	45.2	625.0	140.0	65.6	77.3
G	32	69.6	42.6	595.0	142.7	64.3	79.6
G	33	76.8	42.2	598.0	138.3	61.5	73.8
G	35	66.7	39.6	555.0	136.3	58.0	73.2
G	36	58.0	38.7	449.0	114.7	49.0	57.2
G	37	67.9	38.3	547.0	138.3	59.7	76.5
G	38	61.9	40.2	560.0	133.1	53.5	70.1
G	39	67.5	44.9	600.0	145.2	58.6	78.7
G	1	61.0	37.2	510.0	119.6	52.1	65.3
G	2	68.8	42.6	563.0	136.0	62.1	75.4
G	3	67.1	42.1	569.0	132.0	57.8	72.9
G	4	64.2	41.5	540.0	123.0	54.9	66.0
G	5	64.7	45.2	555.0	141.5	57.4	85.2
G	6	73.9	48.0	631.0	150.6	66.0	84.5
G	7	75.3	46.7	627.0	140.3	61.1	75.4
G	8	58.8	39.0	529.0	126.9	54.7	71.7
G	9	67.0	38.9	552.0	125.8	54.5	69.1
G	10	67.9	36.6	543.0	131.1	57.1	75.0
G	11	66.7	42.3	535.0	121.4	54.6	66.3
G	12	64.1	43.3	571.0	128.6	53.8	69.1
G	13	58.8	34.6	465.0	112.0	49.8	62.2
G	14	60.3	39.7	511.0	117.7	50.3	64.7
G	15	66.5	40.2	556.0	133.0	56.5	74.9

G	16	82.1	53.4	674.0	153.0	71.4	91.4
G	17	68.4	41.0	573.0	129.9	54.3	73.2
G	18	71.3	39.2	565.0	141.6	59.9	82.2
G	19	74.5	43.9	584.0	135.1	60.3	74.2
G	20	62.6	38.6	527.0	129.2	55.4	74.4
G	21	74.4	44.7	613.0	147.8	63.9	84.3
G	22	67.2	39.7	537.0	122.4	55.6	67.1
G	23	66.7	44.4	551.0	129.5	56.3	70.9
G	25	73.3	46.0	613.0	150.7	64.8	86.3
G	26	76.2	48.5	646.0	153.0	68.0	94.4
G	27	71.7	43.8	613.0	137.1	60.3	77.3
G	28	73.8	48.6	619.0	149.1	64.4	90.0
G	29	66.8	34.1	514.0	118.3	54.8	67.0
G	30	71.8	44.9	564.0	132.6	57.3	72.8
G	31	63.5	41.5	528.0	120.5	50.4	63.6
G	32	69.5	41.1	568.0	133.1	55.6	73.3
G	33	77.1	44.9	598.0	145.4	61.8	71.4
G	34	43.6	30.1	394.0	94.5	38.6	52.2
G	35	73.0	45.2	615.0	140.6	60.0	80.8
G	36	64.1	41.4	552.0	124.3	53.3	71.0
G	37	62.8	43.0	556.0	127.9	53.6	70.8
G	38	75.9	49.9	611.0	147.1	62.7	83.7
G	39	66.9	41.2	534.0	124.4	54.7	68.8
G	40	61.7	37.5	438.0	119.7	54.8	64.2
G	41	64.0	41.0	538.0	148.4	50.8	64.5
G	42	63.1	38.0	502.0	118.4	55.1	65.2
G	43	63.0	36.8	522.0	123.6	50.1	66.2
G	44	78.0	49.6	631.0	153.0	65.8	89.0
G	45	75.1	46.7	631.0	145.9	62.1	80.5
G	46	62.2	41.8	554.0	122.3	52.5	68.5
G	47	85.1	49.9	645.0	153.0	72.9	87.2
G	48	66.2	43.6	568.0	132.2	58.8	74.9
G	49	58.8	43.7	541.0	122.5	52.1	68.3
G	50	66.1	43.6	560.0	138.7	56.4	79.0
G	51	66.4	38.4	543.0	128.3	53.1	67.2
G	52	60.0	40.6	524.0	120.1	44.7	64.7
S. Gold	1	57.6	34.0	483.0	107.0	47.6	55.5
S	4	80.4	48.7	696.0	153.0	67.6	87.5
S	5	67.0	41.1	561.0	126.8	52.1	70.7
S	6	59.7	39.0	517.0	126.6	52.0	69.2
S	7	54.2	34.5	466.0	109.7	45.2	56.8
S	8	83.1	50.1	672.0	153.0	62.6	88.2
S	9	63.8	42.9	529.0	124.2	58.1	68.7
S	10	53.3	36.6	484.0	120.9	51.6	68.1
S	11	55.9	40.6	493.0	121.7	54.2	61.9
S	12	64.0	40.4	550.0	123.8	54.1	68.6
S	13	44.2	29.6	384.0	89.1	34.8	47.4
S	14	45.3	28.4	387.0	90.0	38.6	49.6
S	15	78.5	52.5	682.0	153.0	71.0	77.9
S	16	69.1	45.3	576.0	153.0	58.4	79.5
S	17	68.9	46.6	566.0	136.6	58.5	83.0
S	18	70.5	44.0	589.0	132.9	59.9	74.5
S	19	55.2	35.5	453.0	102.3	42.3	57.6
S	20	65.1	40.9	518.0	115.9	55.6	68.1

S	21	60.6	40.5	545.0	120.3	48.8	65.1
S	22	79.5	51.3	679.0	148.0	69.1	86.1
S	23	71.4	47.7	626.0	132.9	58.3	73.0
S	24	67.2	40.6	564.0	121.1	54.2	69.4
S	25	60.1	40.3	530.0	116.7	52.3	70.5
S	26	83.7	49.4	649.0	149.3	64.3	84.8
S	27	52.6	32.7	436.0	99.8	44.7	53.8
S	28	69.9	44.8	617.0	137.3	60.4	73.4
S	29	68.7	39.6	544.0	123.3	57.2	70.6
S	30	79.4	47.2	664.0	144.5	68.4	81.9
S	31	89.3	51.9	732.0	153.0	73.5	90.7
S	32	61.5	38.3	530.0	120.1	54.9	72.2
S	33	57.6	34.7	488.0	107.9	45.6	60.1
S	35	65.2	41.7	566.0	130.1	54.1	71.1
S	36	81.9	46.6	644.0	152.4	68.3	80.4
Trestle	1	46.0	31.5	405.0	104.0	43.3	53.0
T	3	70.5	45.1	576.0	135.7	60.3	73.6
T	4	68.6	43.7	572.0	135.6	61.2	72.2
T	5	81.9	50.2	643.0	151.0	68.1	82.7
T	6	70.0	43.1	563.0	127.6	51.6	70.2
T	7	60.7	42.1	540.0	127.1	54.1	72.2
T	8	56.0	37.1	484.0	111.6	46.8	59.8
T	9	42.5	31.3	410.0	92.3	40.2	48.8
T	11	58.6	39.5	515.0	125.1	54.4	70.2
T	13	45.2	30.4	410.0	97.1	39.0	52.5
T	14	58.1	39.1	515.0	119.8	54.3	65.6
T	15	54.9	35.3	449.0	106.4	49.5	61.7
T	17	70.4	46.9	583.0	145.0	59.4	79.7
T	18	62.0	43.6	505.0	119.1	56.0	72.8
T	19	60.6	44.4	542.0	133.4	56.1	75.8
T	20	56.7	40.3	495.0	119.1	53.7	66.6
T	21	56.0	34.4	566.0	110.9	45.9	59.4
T	22	58.2	39.2	503.0	114.5	51.8	62.3
T	23	71.7	45.9	594.0	138.1	59.4	76.1
T	24	62.2	38.7	503.0	122.3	53.9	73.4
T	25	58.9	39.1	476.0	113.9	52.3	63.2
T	26	69.6	40.3	519.0	127.9	57.1	71.1
T	27	64.9	46.1	568.0	140.9	58.0	81.4
T	28	57.3	35.2	470.0	109.5	50.5	63.8
T	29	58.9	37.0	481.0	118.3	52.8	71.3
T	30	60.9	38.2	515.0	121.9	50.1	67.1
T	31	66.9	40.3	561.0	128.2	55.6	74.0
T	32	60.9	39.6	545.0	121.9	52.0	68.7
T	33	49.0	32.6	423.0	99.3	42.6	52.5
T	34	65.5	40.9	542.0	122.3	57.1	69.9
T	35	61.1	38.8	524.0	120.1	49.7	64.2
T	36	59.5	37.5	475.0	110.7	50.0	62.7
T	37	51.9	36.7	467.0	113.5	45.9	66.5
T	39	57.6	39.5	509.0	114.6	49.8	64.7
T	40	61.0	42.2	451.0	131.0	56.5	70.8
T	41	63.0	39.4	463.0	127.8	52.3	72.9
T	42	58.6	34.7	509.0	123.0	49.1	65.7
T	43	64.9	40.3	531.0	118.5	53.2	67.0
T	44	59.7	36.0	497.0	116.6	50.4	65.2

T	45	50.6	32.6	434.0	103.5	45.9	56.4
T	46	64.8	47.4	636.0	131.3	55.0	72.2
T	47	60.7	42.2	527.0	129.0	53.3	73.4
T	48	57.4	34.7	504.0	117.1	50.4	62.9
T	49	49.0	32.0	420.0	99.8	41.5	53.4
T	50	51.9	34.0	464.0	114.3	49.7	62.8
T	51	50.5	33.2	454.0	113.0	45.3	59.6
T	52	54.5	35.6	493.0	111.8	47.7	61.4
T	53	46.1	29.2	392.0	94.8	41.3	50.9
T	54	68.3	47.8	603.0	140.3	61.5	82.0
T	55	60.7	41.0	543.0	127.1	55.8	69.6
T	56	58.4	35.2	464.0	108.9	45.4	60.7
T	57	51.8	33.0	447.0	109.5	46.4	62.9
T	59	65.6	43.1	565.0	130.7	51.7	71.9
T	60	59.9	39.4	501.0	113.7	48.4	59.8
T	61	54.5	41.3	533.0	123.8	55.9	70.8
T	62	69.6	46.6	628.0	143.7	63.2	78.3
T	63	61.4	39.5	512.0	118.7	52.2	66.2
T	67	71.9	49.4	637.0	143.9	61.1	83.9
T	68	65.9	40.7	531.0	124.8	59.3	68.9
T	71	57.8	35.5	491.0	120.3	48.4	63.7
T	72	52.6	30.4	425.0	96.6	42.4	51.0
T	74	55.6	35.4	490.0	119.2	50.8	64.4
T	75	64.9	42.0	572.0	121.2	53.7	66.7
T	76	66.9	40.5	535.0	130.7	51.7	73.9
T	77	70.2	43.8	567.0	128.5	57.1	72.4
T	79	70.2	44.3	596.0	138.1	60.8	80.3
T	80	71.0	48.3	585.0	138.3	63.0	82.0
T	89	61.4	42.7	543.0	129.8	55.9	70.5
T	91	62.2	42.0	550.0	127.0	55.5	71.6
T	92	59.8	36.6	473.0	111.4	51.7	59.7
T	99	70.1	42.7	548.0	133.7	55.9	79.3
T	100	53.3	33.5	461.0	107.9	47.4	57.0
T	1	84.3	45.7	628.0	147.6	62.2	82.6
T	2	48.8	29.0	417.0	96.8	39.1	53.3
T	3	74.4	39.9	565.0	144.5	59.4	78.0
T	4	64.0	40.9	557.0	125.0	49.5	68.3
T	5	65.0	39.4	549.0	130.1	53.6	73.4
T	6	61.2	38.6	516.0	123.4	51.8	66.6
T	7	58.4	35.8	479.0	108.2	49.5	61.2
T	9	59.2	39.6	538.0	126.8	56.9	71.4
T	10	61.2	41.9	539.0	129.8	53.6	69.3
T	11	57.7	40.1	536.0	125.2	50.8	68.6
T	12	63.0	39.4	504.0	112.8	55.6	62.0
T	13	48.0	35.8	456.0	102.9	39.6	54.9
T	14	66.8	44.2	571.0	129.8	54.1	72.9
T	15	54.9	38.9	484.0	111.3	50.3	62.2
T	16	54.6	33.8	442.0	105.9	46.0	57.7
T	17	62.5	38.8	521.0	121.6	54.7	64.7
T	18	58.2	34.9	473.0	107.8	50.1	57.9
T	19	60.5	41.9	551.0	124.2	48.5	72.6
T	20	57.0	39.1	515.0	117.6	49.9	65.4
T	21	69.0	47.0	580.0	136.1	69.0	77.7
T	22	66.1	40.3	554.0	129.9	57.1	52.9

T	23	54.2	35.6	448.0	109.1	50.2	60.6
T	24	53.5	32.3	420.0	105.6	44.3	58.3
T	25	65.6	35.8	503.0	114.9	53.3	64.1
T	26	61.5	35.3	470.0	117.3	51.5	63.3
T	28	77.5	52.5	648.0	154.9	66.8	86.2
T	29	80.9	50.4	650.0	151.9	64.7	80.3
T	30	60.2	41.5	518.0	116.2	53.0	66.0
T	31	64.6	42.2	559.0	124.2	56.3	66.4
T	32	71.6	47.8	595.0	144.6	66.9	77.3
T	34	64.0	41.0	542.0	126.1	56.4	72.3
T	35	64.9	45.0	573.0	127.8	56.0	69.0
T	36	40.2	30.6	412.0	96.1	38.8	52.0
T	37	70.4	42.6	566.0	138.8	59.7	76.2
T	38	59.2	37.1	490.0	121.5	50.8	67.0
T	39	67.2	46.6	585.0	132.3	57.8	73.3
T	40	53.0	37.2	473.0	107.3	48.6	57.6
T	44	82.4	48.7	630.0	150.3	64.1	86.2
T	45	81.7	46.7	598.0	140.7	63.4	75.7
T	46	64.8	46.8	588.0	139.9	57.2	80.3
T	47	80.3	48.3	617.0	144.2	65.2	80.3
T	48	65.4	41.1	550.0	122.3	49.7	67.9
T	49	66.0	41.9	532.0	117.0	53.9	66.1
T	50	63.5	40.0	515.0	118.8	50.0	63.1
T	51	77.2	47.3	619.0	138.0	62.5	80.8
T	52	76.0	46.9	609.0	144.6	64.2	78.1
T	53	63.4	41.5	535.0	122.9	49.4	73.3
T	55	65.0	42.5	506.0	140.2	56.3	70.0
T	56	53.1	33.4	472.0	123.5	49.8	74.2
T	57	71.2	42.8	573.0	132.5	58.8	69.7
T	58	67.7	41.4	529.0	124.7	54.6	68.2
T	59	64.9	40.3	536.0	120.4	53.1	65.5
T	60	77.2	46.1	654.0	150.7	62.9	82.0
T	62	60.3	38.4	490.0	109.3	50.5	59.2
T	63	69.1	44.8	612.0	144.2	68.8	84.5
T	64	57.6	35.1	473.0	116.6	47.8	63.6
T	65	66.1	47.3	579.0	137.5	61.9	78.3
T	51	79.5	49.2	660.0	152.8	68.2	85.0
T	52	63.9	40.8	520.0	119.4	54.9	67.6
T	53	84.5	49.2	647.0	142.4	63.8	89.1
T	54	67.5	44.9	558.0	127.8	54.4	73.5
T	55	73.1	46.0	605.0	137.3	58.3	77.3
T	56	62.4	38.9	490.0	118.5	49.7	64.6
T	57	53.8	35.7	447.0	112.0	45.9	59.2
T	58	72.4	47.2	612.0	144.6	65.5	75.1
T	60	80.8	47.4	629.0	149.5	64.7	80.2
T	61	64.7	39.0	503.0	123.5	51.8	66.5
T	62	79.4	40.9	615.0	154.2	64.5	83.9
T	63	53.4	34.1	435.0	107.7	46.1	60.4
T	64	61.3	39.6	514.0	122.0	49.4	69.2
T	65	76.6	45.9	579.0	140.2	59.4	77.3
T	66	62.3	37.3	484.0	117.1	49.7	63.6
T	67	58.7	39.8	496.0	120.1	52.7	64.0
T	1	72.0	56.4	559.0	139.9	63.2	80.0
T	2	47.7	32.9	425.0	109.0	42.8	60.0

T	3	52.6	40.7	452.0	109.8	45.4	59.6
T	4	61.8	47.7	586.0	140.3	57.9	75.4
T	5	67.3	48.8	588.0	138.1	50.5	77.0
T	6	65.9	45.0	560.0	129.7	52.4	72.7
T	7	64.6	49.7	560.0	127.1	56.4	58.3
T	8	60.2	51.7	585.0	135.9	52.7	74.3
T	9	71.7	51.8	583.0	131.3	60.0	72.3
T	14	63.1	43.2	563.0	129.9	56.8	73.0
T	15	61.8	37.0	494.0	117.3	50.6	69.9
T	16	72.2	43.6	624.0	146.3	59.3	83.5
T	17	62.7	40.6	542.0	128.5	53.4	68.2
T	18	63.0	38.1	536.0	127.5	52.0	68.4
T	19	54.2	41.4	543.0	123.2	53.2	68.3
T	20	56.2	38.5	511.0	113.8	49.3	63.9
T	22	64.4	44.6	579.0	132.9	57.4	73.8
T	23	57.9	37.4	493.0	116.0	51.1	65.1
T	25	57.3	39.7	502.0	119.9	50.5	60.7
T	26	63.4	44.1	590.0	130.5	58.9	70.9
T	27	57.3	37.4	512.0	117.5	51.4	62.7